alloy plating layer directly onto the conventional Fe-Ni alloy (42 alloy) is bonded using an Sn-Ag-Bi alloy solder. In this combination, Pb-Bi compounds agglomerated at the interface and fracture occurred in the interface between the 42 alloy and the solder. A small amount of Sn was detected on the fractured 42 alloy surface of the lead and it is believed that the Sn in the solder formed compounds with the 42 alloy of lead. It is believed, therefore, that agglomaration of the above compounds of Pb and Bi at the interface reduced the contact area between Sn and 42 alloy, greatly weakening bonding strength.

Next, Fig. 10 shows an observation result in the case where the Sn-10Pb alloy plating layer was replaced with an Sn-4Bi alloy plating layer. The compound layer formed in the interface was thin and fracture occurred similarly at the interface between 42 alloy and solder. However, Bi remained granular crystals, which do not cause a decrease in the area of bond between Sn and 42 alloy so much as in the case of an Sn-10Pb. It is believed that this is the reason why bonding strength of not less than 5 kgf was capable of being obtained. Auger analysis revealed that the then compound layer is an Sn-Fe layer of about 70 nm.

Fig. 11 shows an observation result in the case where a Cu layer was formed on under the Sn-4Bi layer. It was found that a thick layer of compounds of Cu and Sn is formed in the interface. Fracture

occurred in the interface between this compound layer and the solder or in the compound layer. The fractured surface was almost flat in the case shown in Fig. 10 where the Sn-Bi alloy layer was directly formed on the 42 alloy lead, whereas it was uneven in the case where the Cu layer was present. For this reason, it is believed that this difference in the fractured surface resulted in the improvement in bonding strength. Incidentally, similar investigation results were obtained also from other Sn-Ag-Bi alloy solder compositions.

Occurrence of whiskers was investigated for the above example leads of each composition. The formation of whiskers was observed on the surfaces of the example leads to which an Sn-Zn alloy plating layer was applied. It has been hitherto said that Sn plating presents a problem in resistance to the formation of whiskers. However, the occurrence of whiskers was not observed in the Sn-Bi alloy layers and there was no problem in resistance to formation of whiskers.

Accordingly, with the use of the electrode structures of the invention, the bonding portions excellent in bonding strength, wettability and resistance to occurrence of whiskers can be obtained by means of Sn-Ag-Bi alloy solders.

The reason why Sn-Ag-Bi solders containing Sn as a primary component, 5 to 25 wt% Bi, 1.5 to 3 wt% Ag and optionally 0 to 1 wt% Cu were selected is that

solders of the composition in these ranges permit soldering at 220-240°C and that these solders have almost the same wettability as eutectic Sn-Ag alloy solders, which have hitherto been field proven for Cu, and provide sufficient reliability at high temperatures. More specifically, Sn-Ag-Bi alloy solders have a composition (a ternary eutectic alloy) which melt at approximately 138°C when the Bi content is not less than approximately 10 wt% and it is concerned about that these portions might have an adverse influence on reliability at high temperature. However, the precipitation of a ternary eutectic composition is controlled to levels that pose no problem in practical use and high-temperature strength at 125°C is also ensured. Accordingly, practical and highly reliable electronic articles can be obtained by soldering the above electrode using the solder of this composition.

Example 1:

The cross-sectional structure of a lead for QFP-LSI is shown in Fig. 1. This illustrates a part of the cross-sectional structure of the lead. An Sn-Bi alloy layer 2 was formed on a lead 1 which is of an Fe-Ni alloy (42 alloy). The Sn-Bi alloy layer 2 was formed by plating and its thickness was about 10 μm. The Bi content of Sn-Bi alloy plating layer was 8 wt%. The above QFP-LSI having this electrode structure was